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ABSTRACT

This document provides science curriculum instructional material relating to marine biology. Items presented relate to live animal exhibits seen during visits to Sea World marine aquarium exhibits; however, all materials are also useful for in-class instruction without visits to Sea World displays. Ideally, material shcuild be reviewed immediately prior to a Sea World exhibit. This unit has a theme of adaptation and includes transparencies and information sheets on tide pools, sea otters, marine mammal adaptation, adaptations of fish and aquatic invertebrates, and social adaptations cf sea life. (SL)

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SEA WORLD Curriculum Guide

Program Theme: ADAPTATIONS K-3

A SEA WORLD EDUCATIONAL PUBLICATION
Courtesy of Atlantic Richfield Company

SE 022 543

SEA OTTER INFORMATION SHEET

9/74 KW

9/12/74 KW

The Sea Otter -- Enhydra lutris

I. Scientific classification
   A. Scientific name - Enhydra lutris, only member of genus Enhydra.
   B. Belongs to the mustelid family which includes skunks, weasels, badgers and river otters. (scientific name-Mustelidae)
   C. Largest of all otters
   D. Believed to have gone from land to sea about one or two million years ago in Asia.
   E. Smallest marine mammal; only marine mammal of order Carnivora
   F. There is controversy over whether the northern (Alaskan) sea otter and the southern (Californian) sea otter are two distinct subspecies because their diet and feeding habits and amount of time spent on land vary. However, there is no evidence that they are separate subspecies, their differences being explicable by variations in habitat opportunities.

II. Habitat and Distribution
   A. The sea otter used to be found from the coast of Japan up through the Kurile Islands and the Commander Islands, across the Aleutian Islands, down the coasts of Alaska, Canada, western United States to Baja California-an area known as the "furry crescent."
   B. Today, the sea otter lives in shallow waters off of Alaska and the Aleutian Islands, the Commander Islands and along the California coast from Monterey to Point Conception.
   C. Habitat requirements
      1. Prefer kelp beds, but not essential
         a. Kelp provides camouflage with its network of heavy stems and froms.
         b. The stipes and blades help quiet the water.
         c. By wrapping it around themselves, otters use kelp to prevent from drifting and from being dashed against rocks.
         d. The kelp forest supports many of the organisms otters feed on.
      2. Live in rocky coastal areas near points of land where some areas are protected from wind and waves.
      3. Concentrate and form colonies in areas which offer abundant invertebrate bottom fauna.
   D. Otters do not migrate as many other marine mammals do.
   E. Population today
      1. In California there are between 1600 and 2000 animals spread over about 140 miles of coast.
      2. Total world population is over 50,000 animals

III. Longevity-in ideal situation, a wild sea otter may live from 15 to 20 years.

IV. Physical Characteristics

A. Fur
1. Brown to black fur, finest, most dense and most valuable of any animal.
2. On a large animal, there are estimated to be just under one billion fur fibres, 650,000 hairs per square inch, twice as much as the fur seal.
3. Head gets whiter with age on both sexes but males are lighter in general.
4. General grizzling of hairs with age.

B. Measurements
1. An adult male reaches a maximum weight of 100 lbs. averaging between 60 and 80 lbs.
2. An adult female may weigh more than 75 lbs., but averages between 40 and 60 lbs.
3. Males average 4 1/2 feet in length, females about 4 feet, including tail which takes up about 1/4 of body length.

C. Forelimbs
1. Have small, dextrous paws with retractile claws.
2. Are used for grooming, finding and retrieving food, eating and various behaviorisms.
3. Are not used for swimming.

D. Hind limbs
1. Feet are webbed and flattened, act like flippers; outside toe is largest-makes for more efficient propulsion.
2. Move up and down vertically with tail to dive and swim underwater. Can reach speeds up to 6 mph underwater and dive to over 120 feet.
3. On back, alternately paddle feet, swimming from 1 to 1.7 mph maximum speed.
4. No retractile claws on hind feet.

E. Tail
1. Bluntish and flattened
2. Moved up and down, gives an extra push in swimming.

F. Head
1. Whiskers
   a. Can be moved voluntarily and used for exploring bottom for food.
   b. Can grow to 4" but in wild are worn down by use and are only about 2" long.
2. Teeth
   a. Over half of the 32 teeth are molars and postcanines suited for grinding and crushing food; tips are often worn or broken.
   b. Not used for cutting or shearing flesh.
   c. Lower incisors protrude forward; used to scoop soft food parts from their shell.
3. Ears-pointed, close automatically when dive.
4. Nose-diamond-shaped and flat; muzzle has blunt appearance.

V. Senses
   A. Hearing-average ability, soon become accustomed to human noises.
   B. Smell-this sense is acute; otters will show alarm at smell of humans when they will show no notice of sight or sound of cautious humans.
   C. Sight-good visual acuity, but secondary to smell in air; underwater sight may be useful in finding food.
   D. Taste-has been shown that they prefer certain food by taste.
   E. Tactile-very sensitive, important in finding and choosing food.

VI. Daily Activity Cycle
   A. Awaken and are active within first hour after sunrise
   B. On awakening, briefly groom, seeming reluctant to wet head and forepaws, then feed.
   C. Feeding interspersed with short periods of rest and grooming until mid or late morning.
   D. Rest for two to four hours in midday, covering their eyes with forepaws to keep out sun.
   E. From late afternoon to sunset or shortly after, feeding occurs again along with grooming.
   F. Usually sleep without interruption through the night.
   G. Sleep, rest and travel (except when in a hurry) on their backs
   H. California otters spend entire time in water; Northern otters often sleep, groom and nurse on land.
   I. Homerange
      1. Usually do not swim more than a mile or so from shore.
      2. Homerange of female may include 5 to 10 miles of coastline, males may have a larger one.

VII. Social Behavior
   A. Sea otters are social animals-live in groups ranging from a few dozen to over 100 animals (called rafts).
      The rafts are sexually segregated, females avoiding the male feeding areas.
   B. Otters are non-aggresive; adults rarely fight, even when one steals from another.
   C. Often seen playing together-leap clear of water, make short dives, ride the waves, and chase each other.
   D. Otters communicate with a variety of vocalizations
      1. Pup signals distress or desire for attention with a sharp, high-pitched "waah-waah".
      2. Adult in severe stress, such as mother who has lost her young, utters a scream that can be heard up to half a mile away.
      3. Frustration or mild distress is signalled with a whistle or whine.
      4. Cooing is a sound that females use to express satisfaction and contentment. It comes from the throat and occurs in courtship, when the mother is fondling and grooming her pup or when she is eating something good.
      5. A snarl or growl from deep in throat is made when angry.

6. The male instead of cooing, grunts in satisfaction over food.

E. When otters are in the same area as seals and sea lions, they ignore them, give way to them, and have even been seen to play together with them occasionally. They have no aggressive interactions.

VII. Diet and Eating Habits

A. Constant and high food intake
1. Eats 20 to 23% of body weight daily, 15-20 lbs. of food a day.
2. Necessary to maintain their high metabolic rate, which helps to keep them warm.
3. Lacking the blubber found in other marine mammals, fasting would be fatal to the otter.

B. Food includes: sea urchin, abalone, molluscs such as clams, mussels and snails, crabs and lobsters, squid, octupus.
1. Northern otters eat large amounts of fish and fewer shellfish.
2. Food preference varies from one individual to the next.
3. It is possible that otters are opportunists and feed on the most available food items, acquiring a taste for that which they are most often presented with.

C. Method of collecting food
1. Dive to depths of 120 ft. to retrieve food, rarely deeper.
2. Most dives are about 1/2 to 1 minute long; can endure 4 minutes.
3. Collect food with paws and stuff it under loose skin of their forearm to carry it back to surface.
4. When collecting shellfish, will also pick up a flat rock to use as an anvil for breaking food open.
5. Abalones are removed either by force of paws or by constant hitting with a rock, the shock causing the abalone to release its grip. It may take an otter a dozen or more successive dives to loosen one.
6. Northern otters catch fish with forepaws, unlike other marine mammals which use their teeth.

D. Method of eating
1. Food is eaten in water, lying on back, using chest as a dining room table. Even Northern otters who spend considerable time on land eat all food in the water.
2. The sea otter is one of the few animals that uses a tool. Mussels and other hard shelled organisms are broken by pounding them against a flat rock on the otter's chest or against each other.
3. Soft meat is removed from the shell with paws, teeth or by sucking.
4. Smaller hard shelled organisms are broken with the paws, crushed with the teeth, or sometimes swallowed whole.

E. A feeding hierarchy has been observed.
   1. Larger, dominant animals take food from smaller ones at will.
      a. The victim of theft may occasionally squeal angrily, race after and growl at the thief, the two rushing and diving at each other, but serious fighting does not occur.
      b. The subordinate animal may just pound his chest with his forepaw in sign of frustration.
      c. Smaller animals often eat discarded bits of and less desireable food than larger animals.
      d. A subordinate animal under observation cracked food at bottom of pool and ate it as soon as she surfaced to avoid theft.

F. With their feeding area limited to fairly shallow water and a restricted home range, a large sea otter population can seriously deplete the food resources in its home range, resulting in starvation die-off.

IX. Grooming

A. Grooming is of utmost importance to the health and survival of sea otter.
   1. Having no blubber, otter must depend on his high matabolic rate and the insulation provided by its thick coat.
   2. Fur acts as an insulator by trapping tiny air bubbles, keeping a layer of warm air between the outer surface and skin. Only the tips of fur get wet, these clinging together to form a thin outer layer which keeps water out.
   3. If fur becomes soiled, it loses its insulating qualities and the sea otter dies of exposure.
   4. The otter has no skin parasites-may be the only furred animal that does not.
   5. From 11% to 48% of daylight hours are spent grooming.

B. Method of grooming
   1. Roll and whirl frequently in surf to remove food scraps and slime.
   2. Most grooming is done by rubbing fur with forepaws. The strong claws comb and rake the fur.
   3. Fur is then dried by pressing a fold of skin between the forepaws, squeezing and then removing the water with the tongue.
   4. The otter then rolls over in the water to smooth fur and wet tips.
   5. After washing and drying, fur is aerated: the otter lies face down on water, tucks his head under his chest and blows air into the fur while buffing side with paw.
   6. The sea otter's coat is loose fitting. A pelt from a 4' otter can be stretched to 6 ft. This combined with the extreme flexibility of his body enables the otter to reach all parts of his body.

C. There is no observable molt-appreciable shedding occurs throughout the year. There is, though, a maximum of shedding in late spring and summer and a minimum in midwinter.

X. Mating
- A. Mate at all times of year
- B. Otters become sexually mature at 4 or 5 years of age.
- C. All mating activity occurs in water
  1. Male seeks female, swimming belly down.
  2. If female is receptive, the two engage in playful and affectionate, sometimes aggressive behavior.
  3. Male often grabs female by lower jaw and nose, causing her nose to become swollen and bloody. Females are often observed with white scar tissue around the nose.
  4. After mating, the couple may spend up to three days together, the male always watchful of the female, following her about.
  5. The female deserts the male when he is engaged in other activity, swimming away rapidly beneath the surface of the water. The male, after searching for the female unsuccessfully, will return to the other males.

XI. Birth and Care of Young
- A. Female may conceive at all times but peak birth in summer
- B. Gestation period-there is a period of delayed implantation of undetermined length, but total gestation may be more than a year.
- C. Only one pup is born every other year; it would probably be impossible for a mother to raise more than one pup at a time since she must carry the pup on her chest and groom it frequently and meticulously.
- D. Pup at birth
  1. Is born either tail or head first in the water.
  2. Weigh 3 to 5 lbs. and is a maximum of 2 ft. long.
  3. Fur is shaggy and yellowish, longer than an adults- keeps him afloat while mother dives for food.
  4. Head is light buff similar to adult.
  5. Born with eyes open, with teeth and ability to float. Otherwise is nearly helpless for first month.
  6. Mother carries pup on her chest, cradling it in her forelegs on its back.
- E. Feeding
  1. To nurse, mother lifts pup in her forepaws, turns it around belly down so it can feed from the nipples on her abdomen.
  2. Northern otter may nurse pup on land.
  3. After a month or two pup frequently eats bits of solid food given it by its mother.
  4. While mother dives for food, she will often place pup in patch of kelp with strands wrapped around it to keep from drifting.
  5. Mother sea otter somewhat solitary, but several mothers with young may feed in same area.
  6. Mothers, especially with large young, will often continue to dive for food long after other otters have retired for the night, in the dark, to get enough food for herself and her young.
  7. After nursing, the mother will groom herself briefly, then bathe young, licking it with tongue, digging into the fur with teeth and claws, cooing and soothing the oft-crying pup.

F. Teaching of young
1. Mother begins teaching pup how to swim when it is a few weeks old.
2. She takes it to a quiet pool, slips out from beneath it and stays just out of range, coaxing the crying pup to swim to her.
3. Pup learns first to swim on belly, then on back, later how to dive.
4. It takes much strength and skill to dive since the pup's coat is so buoyant.
5. By two or three months, the pup is swimming beside its mother.
6. Pup first brings up pebbles, seaweed scraps, and other uselss material; by watching its mother, it learns what is useful and good, and to pick up a flat rock for an eating tool.

G. Playful activity
1. Pups spend much time playing with each other, their mothers, and sometimes other adults.
2. Play includes racing, leapfrog, wrestling, somersaults, etc.
3. Other adults usually tolerant, but if show annoyance, mother is quick to defend and protect her young.

H. Protectiveness of mother
1. If mother senses danger, will grab pup by loose fur of the neck and dive with it until they reach safety, coming up for air for pup when necessary.
2. If separated, mother and pup call each other.
3. Mother will defend her young vigorously from any aggressor.
4. Even after death of a pup, mother will hold onto it, grooming and preening it for several days.

I. Mother will care for young until almost as large as she is.
1. Mother grooms and feeds young even when it's able to do so itself.
2. Mother will carry a year old juvenile limp in her mouth if danger presents itself.
3. A year old pup may try to take food away from mother, often without resistance.
4. However, if during a season of stress, a large juvenile begs for food from mother, the mother may desert her young because of lack of enough food for them both.

J. Under some conditions a tolerant adult (male or female) might care for an orphaned juvenile, but such care is not as extensive as that given to a mother's own.

XII. Predation and other causes of death

A. Natural enemies are few
1. Killer whales and sharks known to prey upon otters occasionally but predation is insignificant.
2. When killer whales approach, otter will freeze, play dead or dive for safety in a kelp bed.
3. When sensing danger, will raise forepaws in signal of alarm.

B. Starvation
   1. In overpopulated area, have die-off from lack of food coupled with stress (such as heavy storms).
   2. Most severely hit are the less vigorous juveniles and the old with worn teeth who are forced to use poor quality food.
   3. Even when are past carrying capacity of an area, otters unlikely to cross wide expanses of great depth to find new feeding areas and start new colonies so die-off results.

XIII. In artificial environments
   A. Require special conditions
      1. Must have much clean water and free air circulation.
      2. When conditions are met, otters are highly adaptable to life in artificial environments, they are hardy and appear contented, are placid and tame quickly.
   B. Behavior in artificial environments
      1. Within one or two days among humans, an otter learns to beg for food, forepaws upheld. (This behavior has been observed in the wild, too.)
      2. Otters learn to recognize people who feed them.
      3. Northern otters which do not use rocks as tools since they do not feed on many large, hard-shelled organisms, when given rocks in captivity and given such food, they used rocks to break open food.
      4. Otters have used rocks as hammers on sides and drains of pool.

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TIDE POOL EXHIBIT INFORMATION

The tidal zone is perhaps the Earth's most densely populated area. A variety of plants and animals live here in an area which is both sea and land and never quite the same from one moment to the next. It is an environment which poses unique and often austere conditions to its inhabitants. From the ceaseless heavy pounding of the waves, organisms must find ways to protect themselves from being swept away. Special organs or systems for holding fast to the substrate serve some, while others spend much of their time hiding under rocks or inside rocky crevices. The constant changing of the water level due to tides means the animals living here must be prepared to live with varying amounts of exposure to the drying effects of air. Hard, impermeable shells and thick exoskeletons that slow down evaporation are common answers to this problem. Other organisms contract their bodies or form large tight groups to reduce the amount of surface area exposed, thereby reducing desiccation.

Because the tide pool is often a semi-enclosed, shallow body of water, the salinity levels are constantly changing. Evaporation of water is continually increasing the salinity, and heavy rains and mixing of sea with fresh water runoff lowering salinity. Organisms here must have a wide tolerance or special organs to maintain their particular saltwater balance. Just as salinity is subject to many changes, the temperature of the water may go through wide fluctuations, again requiring wide tolerance of the inhabitants of the pool.

The tidal zone is composed of a number of different habitats. The bottom can vary from soft sand to a rocky floor. The degree of protection and exposure to open surf varies considerably. Any particular area can be divided into upper, middle and lower tidal zones, each with a characteristic distribution of organisms.

The distribution of organisms throughout the intertidal zone is determined by several factors, one of which is the amount of time organisms are exposed to the air during the daily tidal cycle. The high intertidal or splash zone contains plants and animals capable of surviving long periods of exposure with a minimum amount of water. In the mid-intertidal zone organisms spend roughly 50% of their time exposed to the air and 50% covered by water. Many of the animals here have evolved reproductive cycles which coincide with the most favorable of the seasonal tides to insure reproductive success. The lower intertidal area contains the largest number of organisms, many of which can tolerate only brief periods of exposure. Below the lower intertidal is the subtidal region. Here the growth of marine algae is dense and provides cover and foraging space for many species of fish. Many fish remain in the subtidal area during the low tide and follow the returning tide back into the intertidal zone to feed.

STARFISH

Pisaster sp.

Starfish are one of the echinoderms, animals that have spiny skins and which appear radially symmetrical. Pisaster sp. has a central body disc and usually has five long, muscular arms studded with small, rounded white spines radiating out from this disc. On the underside of these arms are hundreds of tube feet. These work on a hydraulic (water pressure) system. On the top of the starfish is a small hole known as the

madroporite. This filters water which goes into the ring canal (part of the interior structure) and then to the tube feet, creating a suction force when the foot is extended. Utilizing the steady, untiring suction of their hundreds of hydraulic powered tube feet, they are able to overcome the muscle power of even their strongest prey. The starfish can use its tube feet to open clams and other molluscs as well as to hold on securely to rocks in areas of heavy, continuous surf where animals with regular muscles would tire and eventually be swept away. The starfish eats by evaginating (turning inside out its stomach and enveloping its food). This technique allows it to eat animals that would otherwise be impossible to obtain from their shells. A starfish's stomach can squeeze through spaces less than 1/100 of an inch. Since the starfish appears radially symmetrical (it really is not since the madroporite is not centered on the body disc) with usually five arms and no head, it can travel in any direction. Also, if it loses an arm or two, it can regenerate new ones and still retain the original number of arms. At the end of each arm is an eye spot (observable if you look closely) which is sensitive to light. On the upper surface of the starfish are minute pincer-like appendages called pedicellarae. These keep the starfish's skin free of parasitic growths such as barnacles by trapping or by grinding up any foreign object that lands on it.

Patiria miniata

Although mainly found in subtidal water, this bat starfish occasionally inhabits the tide pools. It has short webbed arms and appears in many colors ranging through blue, pink, purple, organe, beige and red. You will notice that in the water the bat starfish looks fuzzy. This is caused by its gills, the starfish's means of respiration. The bat star is a scavenger feeding on dead organic material. It also has the ability to evaginate its stomach, engulfing food with its stomach and digesting the food before drawing it and the stomach back into its body.

SEA URCHIN, Strongylocentrotus sp.

The sea urchin is another echinoderm related to the starfish. Like the starfish, it has tube feet, although they are a little harder to observe, and pedicellaria. It is radially symmetrical. Though some sea urchins in other parts of the world are poisonous, the ones here do not have poisonous spines. The spines are strong but break easily if bent sideways (so it is best not to squeeze them). Both the spines and the pedicellaria serve as the urchin's defense system. The purple sea urchin (Strongylocentrotus puspurescens) is the most abundant intertidal urchin. As a protective measure, some urchins will burrow into solid rock or whatever substrate is available, using their spines, which are constantly renewed by growth. An urchin may sometimes imprison itself for life as the opening it drilled when young will be too small for its increased size. The purple sea urchin feeds on seaweek, chewing with its five teeth. It will eat the stipe of kelp, one of it favorite foods, and then the entire plant will float away and eventually die. The red sea urchin (S. franciscanus) has larger, longer spines. The gonads of this animal are eaten raw and considered a delicacy. These urchins primarily eat algae but are also scavengers and will eat almost anything.

SEA CUCUMBER, Stichopus parvimensis

The sea cucumber is an echinoderm like the starfish and sea urchin. It too, has a five-sided body and has abundant tube feet on the lower side of the body. If you hold one underwater, you can see the tube feet move. As the cucumber moves along in the sand, it takes the sand in its mouth, digests the organic material and passes the sand. When handled, the sea cucumber will contract, getting smaller and harder. In some species, when handled roughly, the cucumber will discharge most of its internal organs through the anus, a process known as evisceration. This function serves to confuse a predator, but the lost organs can be regenerated.

SEA ANEMONE, Anthopleura elegantissima

The most abundant anemone on our coast, it often lives in large colonies, sometimes covering an entire rock. They are well camouflaged by bits of gravel they have picked up and put on their sides. When stepped on, water will squirt out from their mouths and the pores in their body walls. When the tide is out, each anemone folds in upon itself, forming a flattened sphere, enabling it to better withstand the drying exposure to air. The larger, green anemone in this pool, Anthopleura xanthogrammica, lives best in rocks embedded in the sand. Specimens of this species have been known to live for over 30 years. On each of the anemone's tentacles are millions of microscopic, spring-loaded stinging cells called nematocysts. When a small fish bumps into the tentacles, he is stung and paralyzed and then drawn into the anemone's mouth in the center. The anemone ingests its prey whole and then spews out any indigestible parts, such as shells and bones. The nematocysts on these anemones are too short to significantly penetrate human skin. The green color of these anemones is caused by microscopic plants that live within the cells of the anemone. This relationship is a form of symbiosis where at least one animal benefits and neither one is hurt by the relationship.

HAIRY HERMIT CRAB, Pagurus hirsutiusculas

The hermit crab lives in discarded gastropo (snail) shells. Its abdomen has a natural twist that even corresponds to the spiral of most snail shells As it grows, it discards one shell and seeks a larger one, always looking for a good fit. It is a scavenger and feeds on the sea floor debris.

KELP CRAB, Taliopus nutalli

This is a hard crab to find, because it spends most of its time hiding in the kelp. Its body is brownish, like the kelp, and its legs are shaped like the kelp stipes. The kelp crab is a grazer and is responsible for stripping the fronds off of entire stipes of kelp. Starting at the holdfast the kelp crab will slowly work his way up to the plant.

SHORE CRAB, Pachygrapsus crassipes

Striped or green shore crab is found in abundance in our local tidepools, It prefers life above the waterline, getting wet only occasionally to keep its gills moist. These crabs are sometimes hard to find because they hide in rocky crevices. Like the spiny lobster, they must molt their hard exoskeleton in order to grow. They can run sideways or backwards when alarmed, and if cornered, will rear up to fight, claws raised. Most of their feeding is done at night on debris, small animals and occasionally algae.

GARIBALDI, Hypsypops rubicundus

The garibaldi is a bright orange extremely pugnacious fish commonly found in coastal waters. When the garibaldi is young, it is almost totally iridescent blue with only a little orange around its nose. As it gets older, the orange color spreads backwards as the blue recedes to a few small dots. The fully mature adult is entirely orange.

It is protected by law and may not be taken for food or harmed in any way. We have a special permit to care for them and display them for the public. The garibaldi is a non-schooling fish. It is very territorial, aggressively defending its cave or cranny. Its bright orange color serves as warning and challenge to other fish.

OPALEYE, Girella nigricans

The opaleye gets its name from the blue-green color of its eyes and may be easily recognized by a white spot on each side just below the dorsal fin. Normally there is only one sopt on each side. However, some have been found with two or even none at all. The opaleye is a schooling fish which follows the tide in and out of the intertidal zone, rarely keeping still. It serves as the host for the lungworm parasite that commonly infects young sea lions.

TIDEPOOL WOOLY SCULPIN, Clinocottus analis

This small sculpin spends all its life in the tidepools and is covered with hair-like cirri. Spotted like the rocks, it blends into its background so well that it can rarely be seen unless it moves. This protective coloration is aided by the sculpin's adaptive behavior of sitting on the bottom among the rocks, rushing out quickly after food. It uses its pectoral fins like arms for support while resting.

Various types of plant life are found in the tidepools. Some of the smallest encrusting algae and the fastest growing plants in the world get their start in tidepools.

GIANT KELP, Macrocystis sp.

This giant brown algae has been known to grow 12-18 inches in a day and is the largest of the marine algae. Many marine organisms depend on this kelp either directly or indirectly for food, and as a place to live or hide from predators. The plant anchors itself to rocks on the bottom by means of a holdfast composed of hundreds of cylindrical filaments. Pneumatocysts (bladders containing carbon monoxide gas) are located at the base of each blade. These act as floats to support the entire length of the stipe on the surface of the water, thus creating a canopy. The ripples in the blades cause turbulence in the water, supplying each blade with more circulation and thus for greater gas exchange and nutrient absorption. The kelp's life cycle is an alteration of generations between a microscopic gametophyte stage and the common large form, the sporophyte. Kelp is an important resource to man and is harvested for its algin, a colloidal substance used as a stabilizer and emulsifier. Algin has the physical property of absorbing large quantities of water. (If one tablespoon of algin is dissolved in one quart of water, the water becomes as thick as honey and can hardly be poured.)

LOBSTER, Panulirius interruptus

The California spiny lobster normally hides in rocky crevices and comes out only at night. The lobster is a scavenger, eating anything it can find in the way of food. Its hard exoskeleton must be shed in order for the lobster to grow. This process of molting may occur as many as four times a year in young lobsters and only once every three or four years in older lobsters. The lobster has five legs on each side, putting it in the decapod or ten-legged group. They can walk forwards, backward, or sideways.

However, to swim it uses its powerful tail and moves rapidly backwards. This is its primary defense. Other defenses are the long antennae thickly set with sandpapery spines, sharp spines on the body and sawteeth on the undersides. The spiny lobster also has the ability to regenerate lost appendages. When molting, instead of growing larger, it will replace the lost legs or antennae. The California spiny lobster is actually more closely related to the crayfish than the lobster. It lacks the large cheliped (front claw or pincer) of the familiar name lobster. Its large, powerful tail is highly prized for eating and in great demand. To prevent their being fished to extinction, they can only be taken at certain times of the year, and must be at lease 3½" from between the eyes to the end of the carapace. It takes about four to six years of growth to reach this size.

ABALONE, Haliotis sp.

In North America, abalone are found only along the Pacific Coast. Here in rocky areas eight different species can be found usually attached to rocks. They are normally very difficult to see, because of the silimarity of their shells to the surrounding rocks. This camouflage is their best defense. They attach themselves by means of a large muscle known as their foot. When the animal is disturbed, this foot creates a suction grip that is so strong that it requires a rigid iron to break it loose. It is this muscle that is considered a seafood delicacy. The legal size for most abalone is 6½" to 7" depending on the species, and it takes an abalone about seven years to grow this large. Abalone are vegetarians, feeding as they travel on algae. They are referred to as gastropods, meaning stomach-foot, because of the close proximity of these two organs. Abalone have a radula like most gastropods, which is a long tongue with many replaceable teeth which is used to literally scrape the rocks as they crawl over them. They are highly valued not only for their meat but also their shell which is used for making jewelry and other decorations.

KEYHOLE LIMPET, Megathura crenulata

Closely related to the abalone, this giant limpet is a gastropod, and is the largest of the keyhole limpet family, measuring up to 7" long. It has an unusual muscular mantle, black to gray in color, which nearly covers the outside of its shell. The velvety color of this mantle is easily removed and will rub off onto your hand if you touch it. The limpet breathes by drawing in water through and over its gills. When oxygen is removed, the water is expelled through the hole in the top of its shell. Waste products are also eliminated through this hole and carried away by the excurrent water. In this way, the animal avoids contaminating the incurrent water before it reaches the gills.

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Adaptations for Survival

The animals that live in the oceans of the world have evolved through thousands of years, so that they are specifically adapted for survival in their own particular eco-niches in a water environment. These adaptations enable them to successfully survive and reproduce; to eat and avoid being eaten.

MARINE MAMMAL ADAPTATIONS

Students will first learn how marine mammals have evolved special adaptations for living all or part of their lives in the water. Their bodies have become adapted for:

Breathing: They instinctively hold their breath and are able to remain submerged for relatively long periods of time. Some breathe through a blowhole located on the top of the head.

Swimming: They have streamlined shapes, and appendages that have developed into fins, flippers and flukes. Their bodies have a layer of blubber which gives them buoyancy and acts as insulation.

Sensing: Their sense of hearing has become highly specialized for use in the water, where sound travels almost 5 times faster than in the air. With their sense of touch, they can detect movements and changes of water pressure, which may be important indicators of food or danger.

ADAPTATIONS OF FISH AND AQUATIC INVERTEBRATES

Where marine mammals have had to re-adapt to a water environment, fish and aquatic invertebrates have evolved directly in the water. Most have gills instead of lungs and can take oxygen directly from the water. Since their body temperatures are the same as the surrounding water ("cold-blooded" animals as compared to "warm-blooded" mammals), they do not require special adaptations to regulate their internal temperatures.

In the endless food cycle of the sea, in order to obtain food and avoid being eaten, these aquatic animals have also had to evolve many special physical adaptations of color, body form and sensory organs.

SOCIAL ADAPTATIONS

Not only have the marine mammals, fish and invertebrates evolved special physical adaptations in order to survive, but also special social adaptations—ways of associating with their own kind, or with others different from themselves, for obtaining food, protection and insuring reproduction.

Teacher's Information

This transparency may be used in comparing swimming and breathing methods in four mammals. The students can see the increasing degree of aquatic specialization from the land dwelling human to the sea lion, which is adapted to both land and sea, to the seal, which spends some time on land but is more adapted to the water, and finally to the dolphin, which is a mammal fully adapted to living in the water.

HUMAN (land)

Breathing: Must lift up head (or roll from side to side) to breathe. Can breathe through nose or mouth. Nostrils are open. Must consciously hold breath underwater.

Swimming: Arms used in pulling motion to move body through water. Must cup hands and hold fingers together. Also uses legs in an up and down motion to move body forward.

SEAL (sea, some land)

Breathing: Lifts head and must consciously open nostrils to breathe. Nostrils are closed underwater.

Swimming: Small front flippers are used for steering or are held against sides when gliding. Large hind flippers provide the propulsion by being sculled from side to side.

SEA LION (land and sea)

Breathing: Lifts head and must consciously open nostrils to breathe. Nostrils are closed underwater.

Swimming: Powerful pectoral flippers are used in an up and down flying motion to move through the water. The hind flippers are used for steering.

DOLPHIN (sea)

Breathing: Has a blowhole on top of head so does not have to lift head to breathe. The blowhole must be consciously opened to breathe. It is closed underwater.

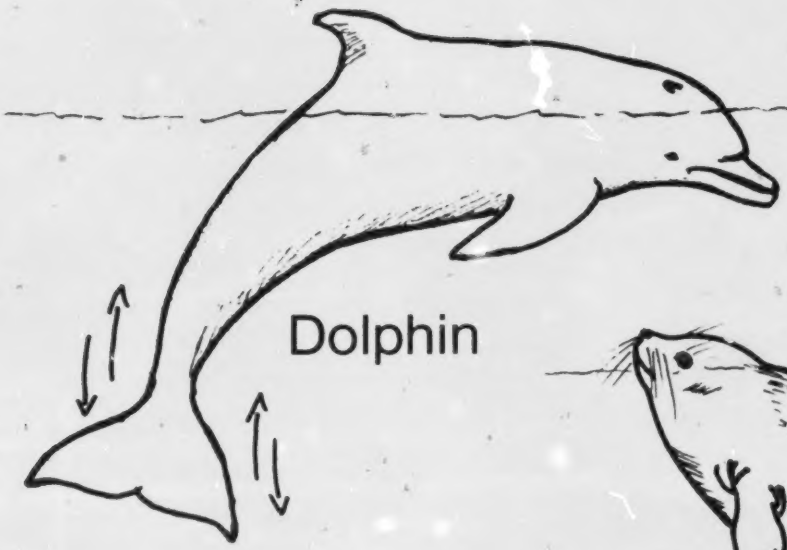
Swimming: The pectoral flippers are used for steering, braking and for stability. The propulsion comes from the use of the tail in strong up and down strokes.

ART EXPRESSION

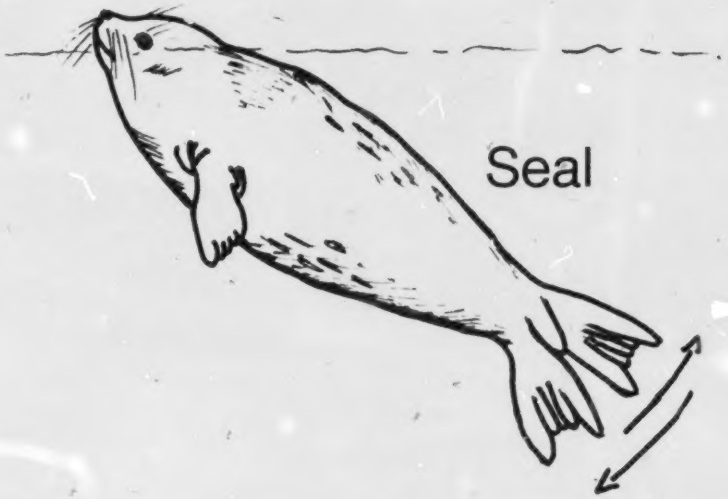
When the students visit Sea World they will be able to observe the graceful, streamlined movements of the marine mammals in the water. The tactile art medias of finger painting or clay modeling could be used to express this grace of line and motion.

Human

Sea Lion



Dolphin



Seal

Transparency 1

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Teacher's Information

Whales and dolphins, like marlin, tuna and sharks live in the sea and are fast swimming predators.

Although the first group are marine mammals and the second group are pelagic fishes, they have evolved many similar adaptations; so much so that whales and dolphins are often mistakenly referred to as fish.

This transparency may be used to illustrate discussions on the similarities as well as the important differences between these pelagic fish and mammals.

SIMILARITIES

Shape: have streamlined, cylindrical "torpedo-shaped" bodies for fast swimming.

Locomotion: have large, wide tail fins or flukes used for rapid propulsion.

Color: are darker on top (dorsal surface) and lighter on the bottom (ventral surface) which makes them difficult to see from above (against the dark bottom) and from below (against the lighter surface).

Feeding: have large mouths with sharp teeth for biting and tearing, but not for chewing. Their diet consists of live crustaceans, fish and in some cases marine mammals and birds.

DIFFERENCES

Locomotion: *Fish* use their body and tail in a side to side motion. These *marine-mammals* use their tails only, in an up and down motion.

Breathing: *Fish* have gills which absorb oxygen directly from the water. *Mammals* have lungs and must breathe air.

Reproduction: Most *Pelagic fish* lay eggs and the young must fend for themselves after hatching. *Marine mammals* give birth to live young which they nurse and care for until old enough to obtain food for themselves.

Temperature control: *Fish* have a body temperature that is the same as the surrounding water (they are "cold-blooded"); no temperature controls necessary. *Mammals* have a body temperature that must remain relatively constant (they are "warm-blooded"). They have a layer of blubber for insulation plus a complex heat exchanging vascular system in their tail and flippers.

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Transparency 2

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Teacher's Information

This transparency may be used to review information concerning the adaptations of fish and invertebrates to their particular econiches in an aquatic environment.

Fish that live in the shallow world of sunlight and shadows of coral reefs, plants and rocks are adapted in different ways than the fast swimming open ocean predators. Bottom dwelling fish and invertebrates are generally slow moving, so have evolved special adaptations to survive. To eat and keep from being eaten in their world, how have these marine animals become adapted for the following:

Locomotion: shape of body, use of fins or legs, etc.?

Protection: coloration, hard shells, sharp or poisonous spines, etc.?

Food getting: small pincher-shaped mouths, tentacles, claws, etc.?

ART EXPRESSION

Make a wall mural ranging from a coral reef to a coastal tidepool with the background executed in finger paints, or poster paints. Have students draw and cut out various marine animals to be placed in their appropriate econiches. Include as many kinds of animals as they can remember from their visit to Sea World, such as —

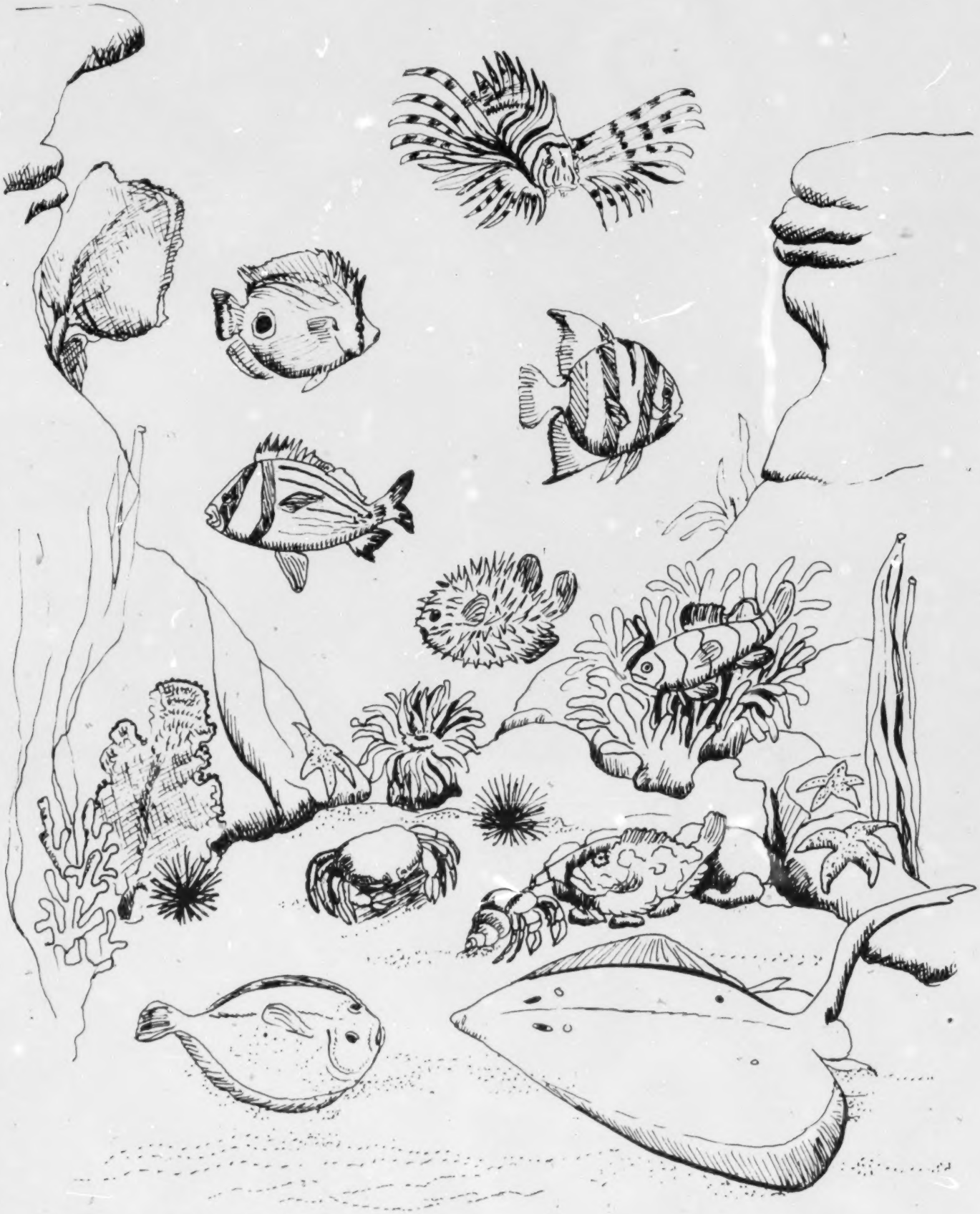
Coral Reef	In or Near Rocks	Sandy Bottom	Tide Pool
Angelfish	Crab	Crab	Limpet
Butterflyfish	Eeel	Starfishes	Chiton
Porkfish	Lobster	Ray	Crab
Porcupine fish	Octopus	Flatfish	Starfishes
Triggerfish	Rockfish	Molluscs	Anemone
Lionfish	Stonefish	Guitarfish	Sea cucumber
Anemone	Starfishes	Sand dollar	Sea hare
etc.	etc.	etc.	etc.

CREATIVE WRITING

Have students choose a marine fish or invertebrate to write about in the first person. For example—"A day in the life of a starfish." Story should include how the animal moves about, finds food (what kind of food and how he catches it), how it keeps from being eaten (hides, swims away, camouflage, sharp spines, etc.) and keeps healthy (visit to cleaner fish).

DRAMATIC EXPRESSION

The children might develop and act out the dialog for a T.V. or radio interview in which marine animals are interviewed to come and live in a Sea World Aquarium or Tide Pool. One child could play the part of the interviewer—a Sea World marine life talent scout, (they might choose a familiar personality to mimic or that *famous* talent scout "Charlie the Tuna.") The other children would choose a fish or invertebrate they would like to represent and tell the interviewer why they are so special and why they are good examples of special adaptations in marine animals.



Transparency 3

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Suggested Extra Reading

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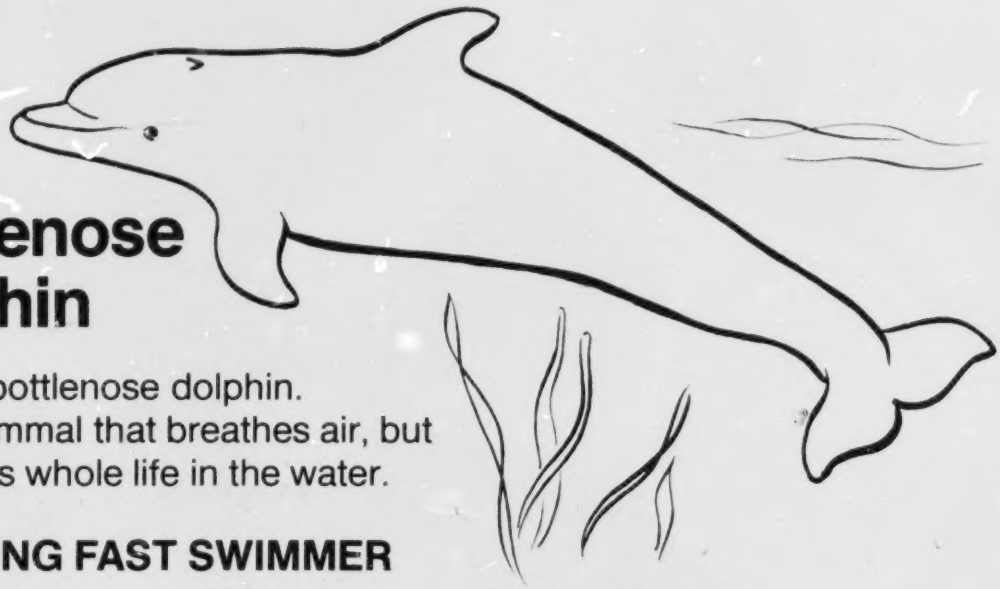

Bottlenose Dolphin

This is a bottlenose dolphin.
It is a mammal that breathes air, but spends its whole life in the water.

A STRONG FAST SWIMMER

The dolphin's body is very smooth, so he can move easily through the water. He has a strong tail that he moves up and down to swim. The dolphin also has two side fins to help him steer in the water and a back fin.

USES EARS TO "SEE" UNDERWATER

The dolphin's eyes are small and often the water is dark and hard to see in, so the dolphin uses his ears to find his way around. A dolphin hears much better than you do, and can tell where things are, and how big or how little they are by bouncing sounds off of them.

BREATHES THROUGH TOP OF HEAD

The dolphin's nose is on the top of his head and is called a blowhole. A dolphin can easily lift his blowhole out of the water to breathe while he is swimming. He does not have to raise his head to breathe as you do when you swim.

WHEN YOU COME TO SEA WORLD –

Look for the dolphin's blowhole. Is it open or closed underwater?

Watch the dolphin swim. How does he swim so fast?

Listen to the dolphin. What kind of sounds does he make?

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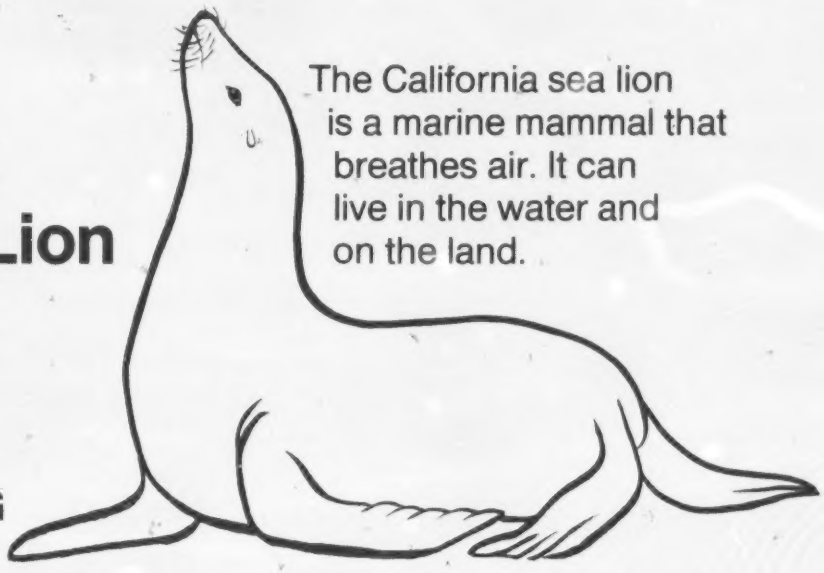
California Sea Lion



The California sea lion is a marine mammal that breathes air. It can live in the water and on the land.

FLIPPERS FOR SWIMMING AND WALKING

A sea lion's front flippers are like your arms and hands, but are covered with skin so they are paddle-shaped. Sea lions swim through the water by moving their flippers up and down like wings. They use their back flippers for steering. Sea lions can bend their back flippers under them for walking on land.

NOSE CLOSED UNDERWATER

A sea lion's nose is closed underwater to keep the water out. He is a very good diver and can stay underwater for 10 or 20 minutes.

"SEES" WITH EYES, EARS AND WHISKERS

On the land, sea lions can see with their eyes. They can also tell what things are like by touching them with their whiskers.

In the water, the sea lion uses his eyes, ears and whiskers to find his way around in the deep dark waters.

WHEN YOU VISIT SEA WORLD –

Watch the sea lion swim. When is his nose open?
How does he use his front flippers to swim?

Watch the sea lion in a show. What does he do with his whiskers?
How does he use his front and back flippers to walk?

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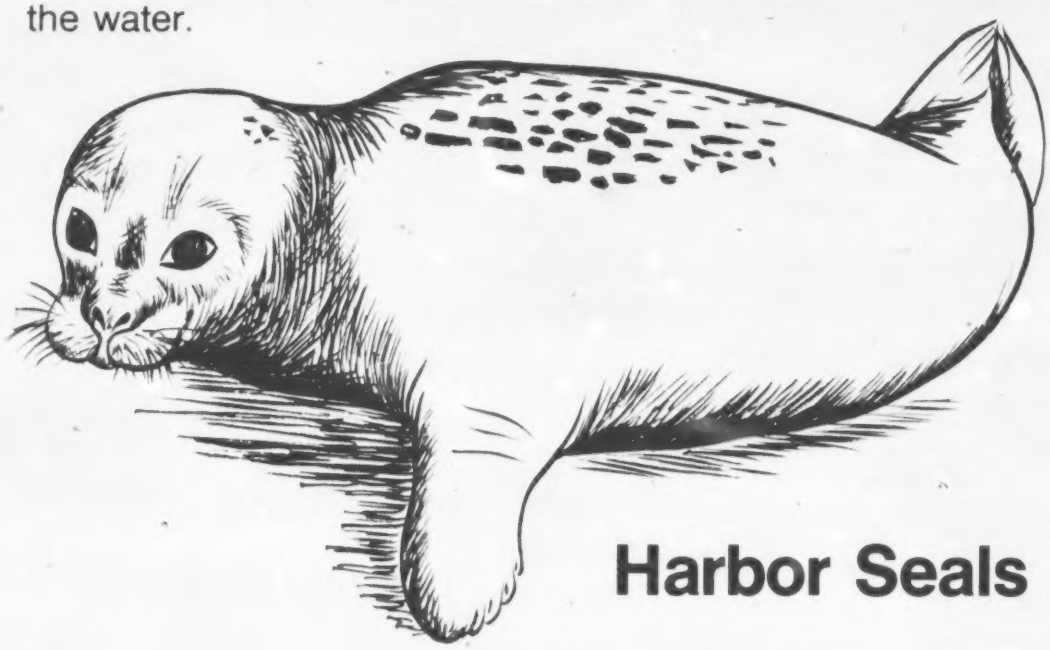
Harbor seals are marine mammal relatives of the sea lion. They can live in the water and on the land too, but are more at home in the water.



Harbor Seals

GOOD SWIMMERS AND DIVERS

On the land seals are very slow and clumsy, because their back flippers will not bend under them for walking, but in the water they are very good swimmers. They use their back flippers to push their smooth rounded bodies through the water. They have a thick layer of blubber to keep them warm while swimming in the cold water.

Seals are also very good divers. They can make long deep dives of 1,000 feet or more to look for food. They can stay underwater for 30 minutes or longer. They have big brown eyes and sensitive whiskers which help them to see and feel underwater.

WHEN YOU VISIT SEA WORLD –

Watch a seal using his back flippers to swim.
What does he do with his front flippers?

Watch the seals in the water.
Can you hold your breath as long as they do?

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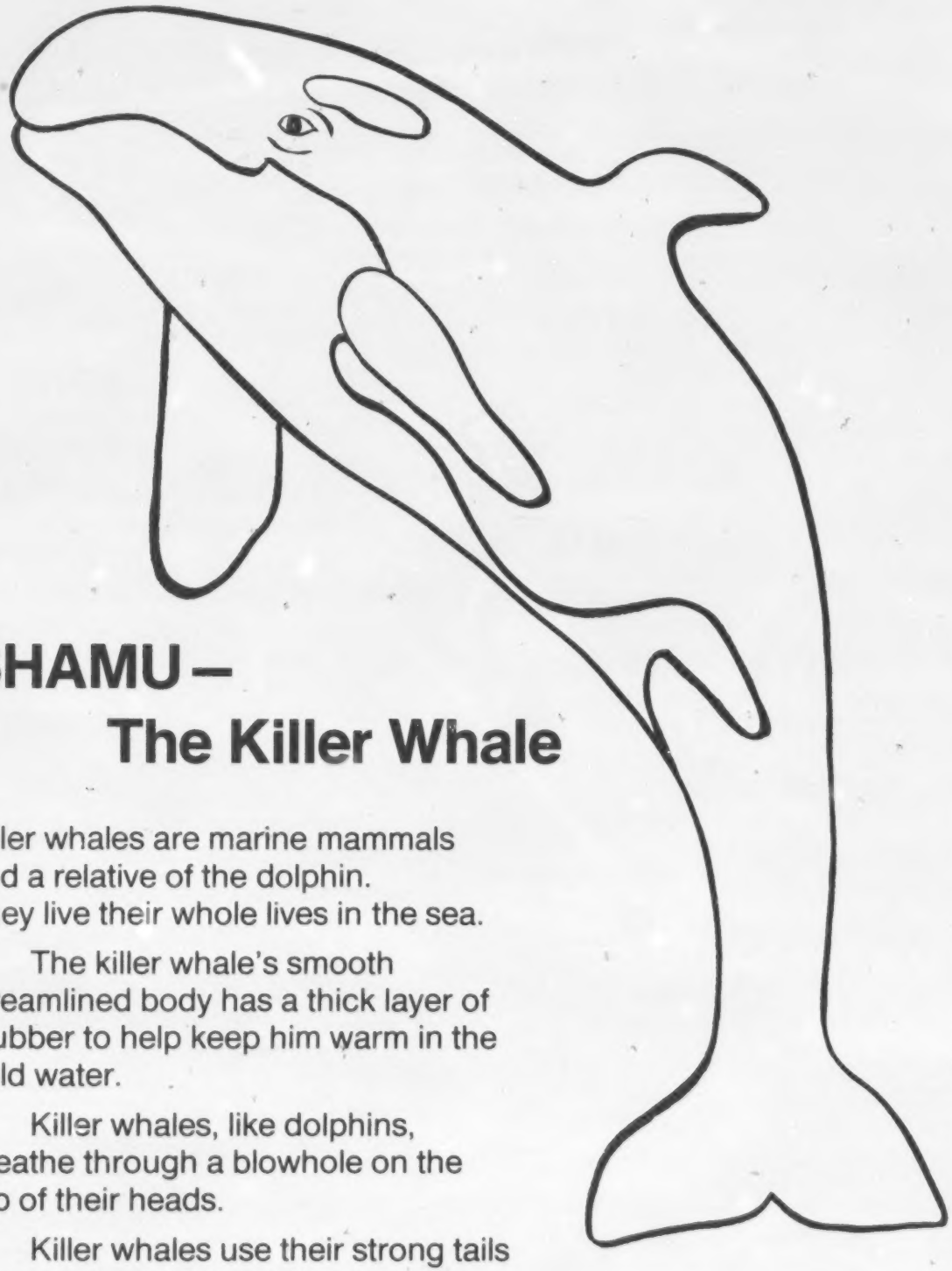

SHAMU – The Killer Whale

Killer whales are marine mammals and a relative of the dolphin. They live their whole lives in the sea.

The killer whale's smooth streamlined body has a thick layer of blubber to help keep him warm in the cold water.

Killer whales, like dolphins, breathe through a blowhole on the top of their heads.

Killer whales use their strong tails in an up-and-down motion to swim very fast and to leap out of the water.

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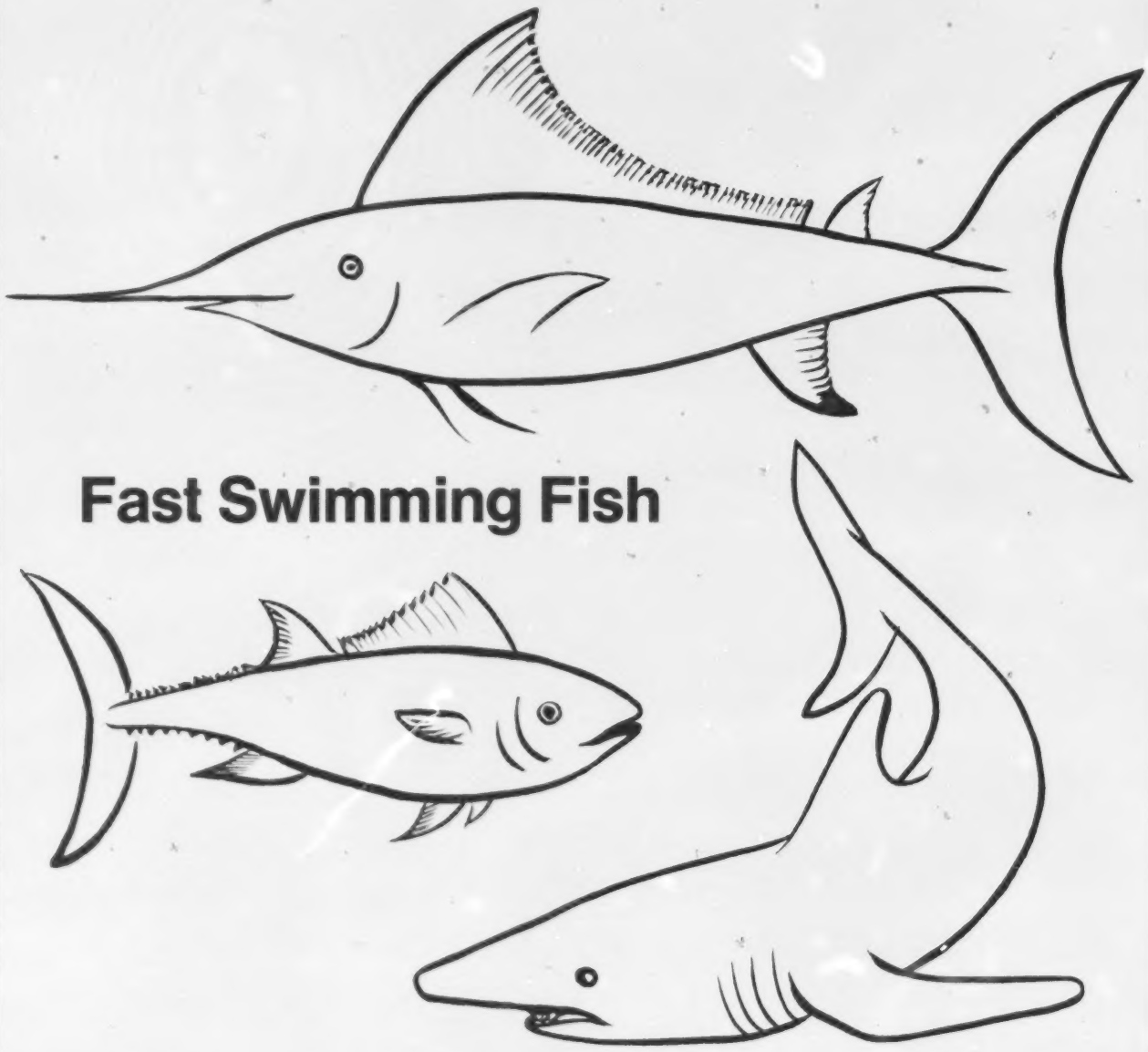

Fast Swimming Fish

Fish that live in the open ocean use their fast swimming ability to catch other fish or to escape from their enemies.

They can swim fast because they have streamlined shapes and wide tails.

They usually have large mouths and many sharp teeth.

They are darker on top and lighter on the bottom. This makes them hard to see from above against the deep dark water and from below against the lighter surface.

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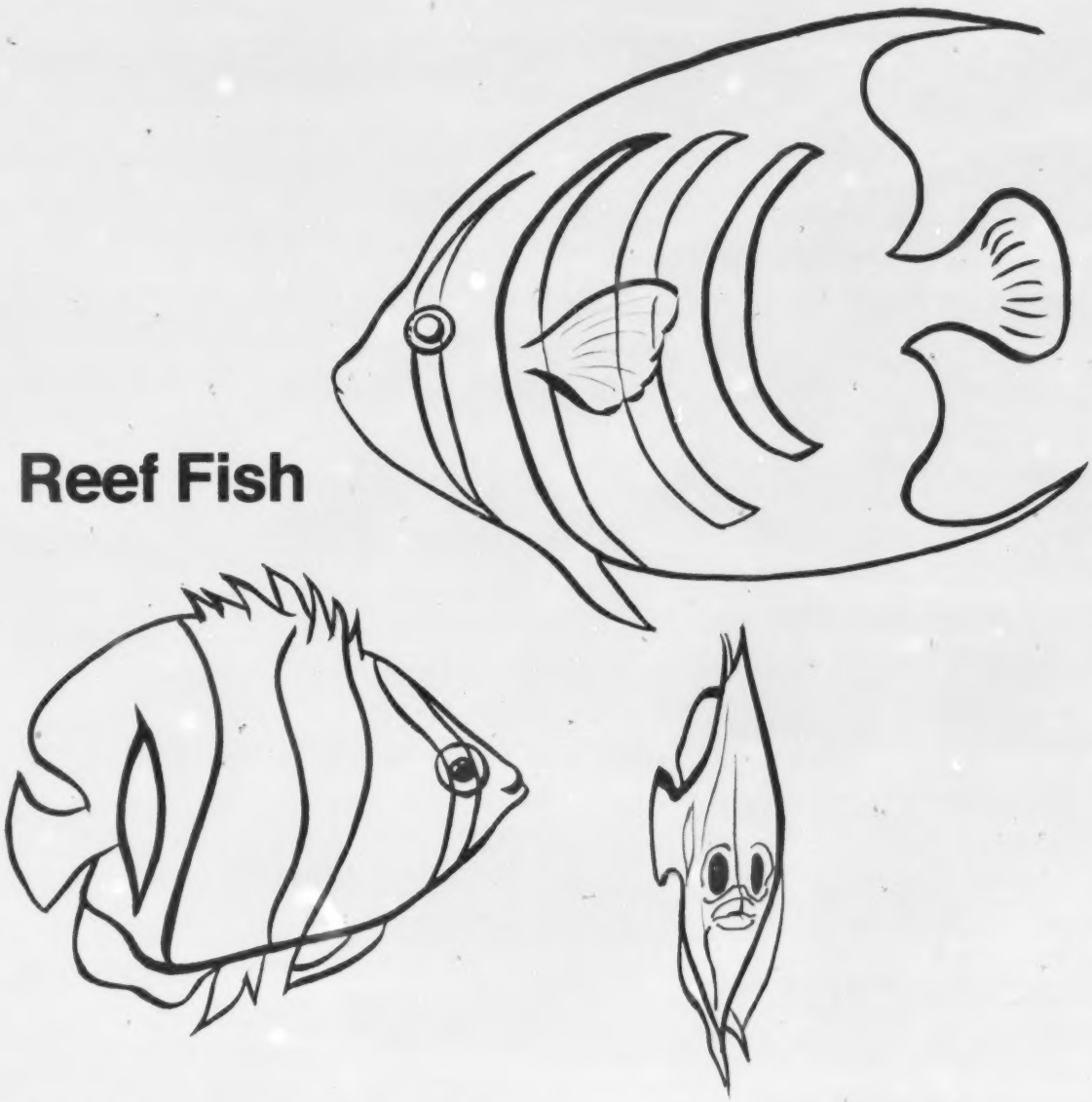
Reef Fish



Fish that live in the colorful reef world of lights and shadows are usually brightly colored, with lines or spots that help disguise the shape of their bodies. Many have false eye spots to fool other fish into thinking they are coming when they are really going.

The bodies of reef fish are usually flattened from side to side, and they have short fan-shaped fins and tails. This makes it easier for them to dart about between the coral, rocks and plants of their homes.

To find food in the cracks and crannies of the rocks and coral, many reef fish have pincher-shaped mouths with tiny teeth.

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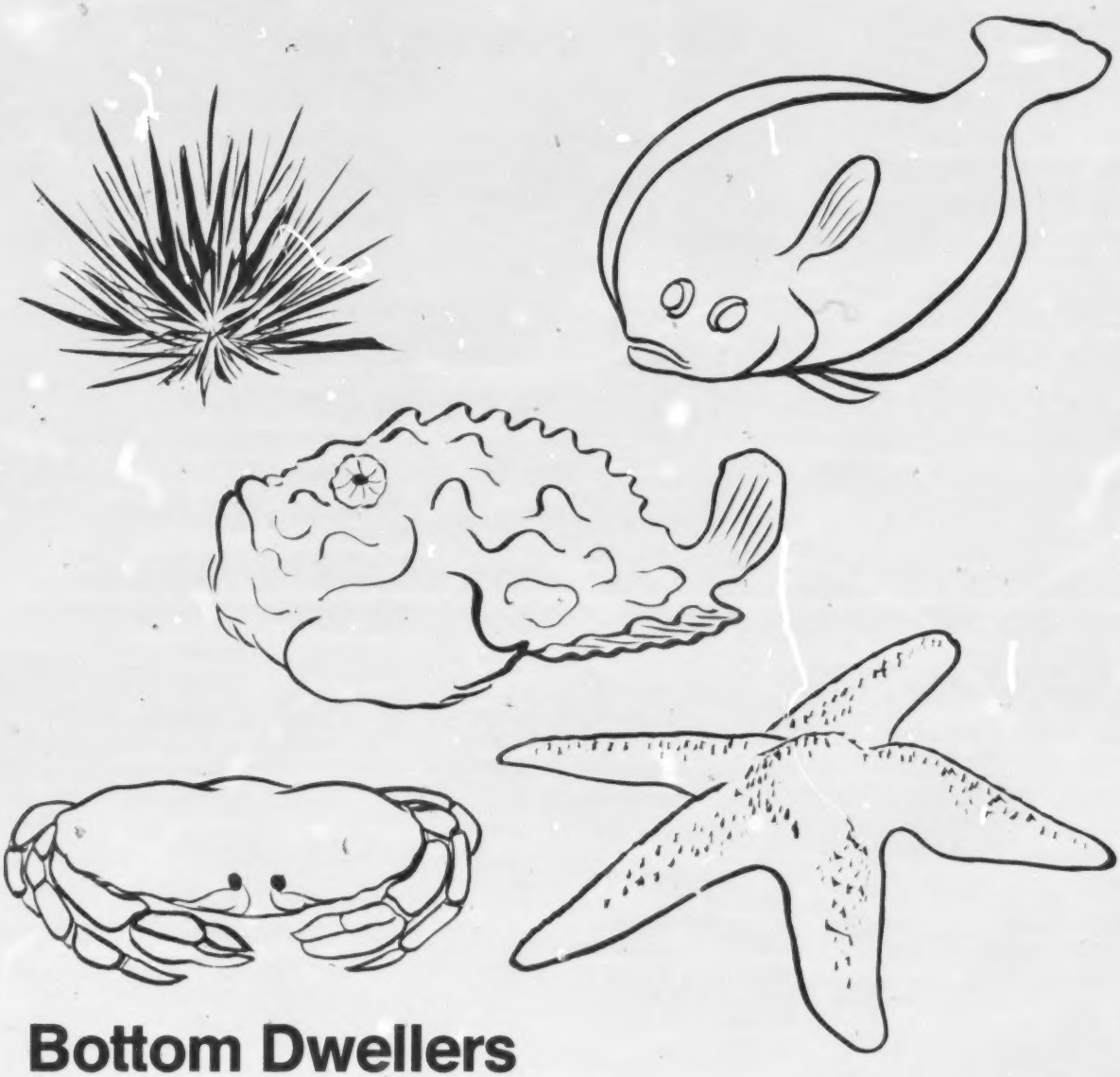

Bottom Dwellers

The bodies of bottom dwelling animals are usually flattened from top to bottom, and their colors often blend with the bottom, making them very hard to see. Can you find the stone fish and the flat fish when you visit Sea World?

Many of the slow moving animals that live on the bottom have hard shells, like the lobster, crab and starfish or have sharp spines, like the sea urchin, to protect them. Some even have poisonous spines, like the stone fish and the stingray.

Many of the animals you will see in the tide pools do not have eyes, but use their tube feet or tentacles to feel for food.

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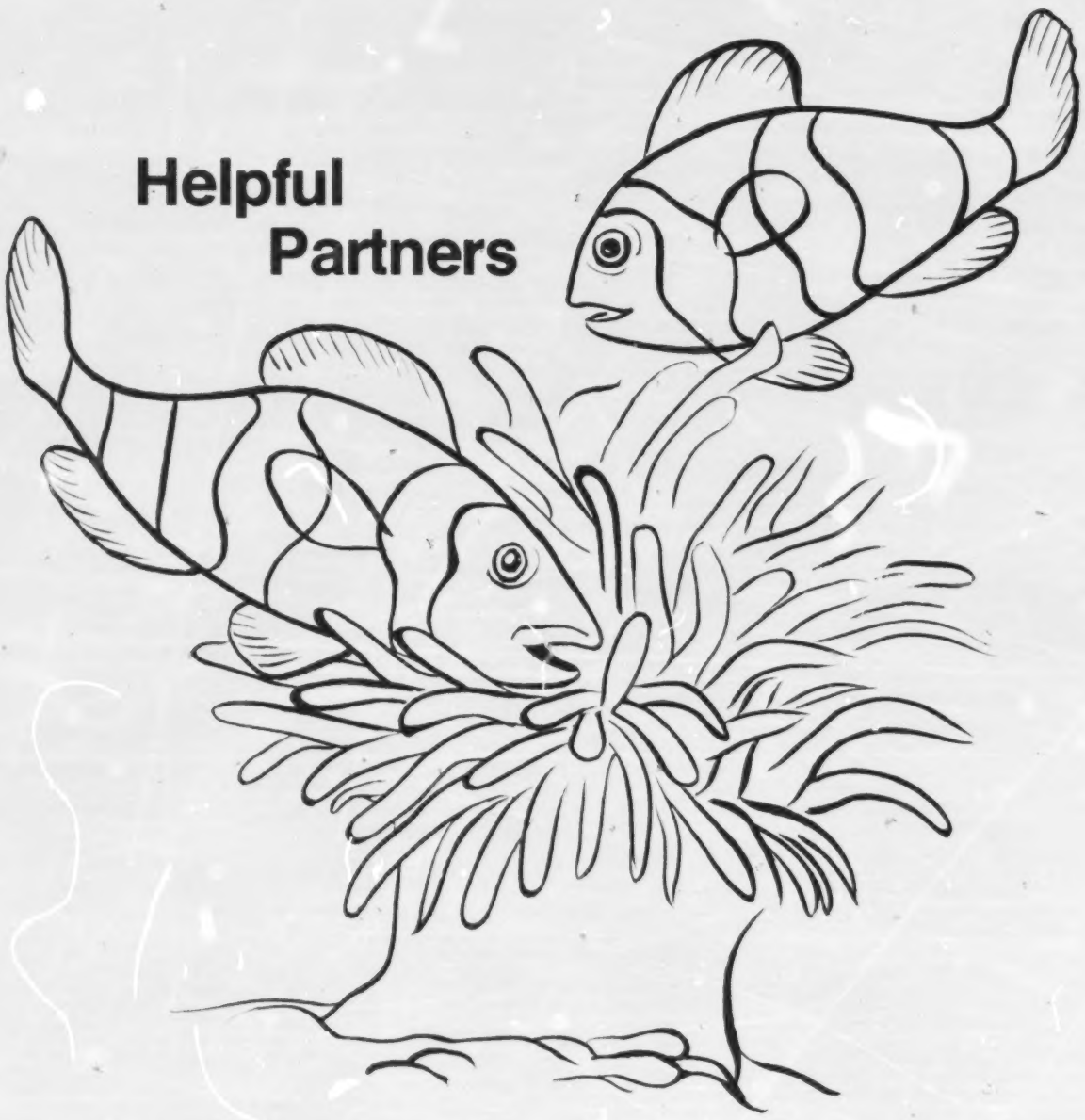
Helpful Partners



The lovely sea anemone looks like a flower but is really an animal.

Anemones have many stinging tentacles which they use to catch their food. To protect themselves, they can pull their tentacles inside and close up like a drawn purse string.

A brightly colored kind of fish, called an anemone fish, can live amongst the anemones' stinging tentacles, which do not hurt it. The anemone protects them from being eaten by other fish; in turn, the brightly colored anemone fish lure other fish for the anemone to catch.

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